

Submitted for publication

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SURVIVAL OF KNEE ARTHROPLASTIES

A Nationwide Multicenter Investigation of 8 000 Cases

by

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ABSTRACTS: A prospective nation-wide study of knee arthroplasty has been ongoing in Sweden since October 1975. By the end of 1983, 4 505 arthroplasties for osteoarthritis (OA) and 3 495 arthroplasties for rheumatoid arthritis (RA) had been recorded and reviewed one, three and six years after the operation.

Using actuarial methods, the six year probability of the prosthesis remaining in situ was calculated. This probability ranged in OA from 65 per cent for hinge prostheses to 90 per cent for medial unicompartement prostheses. Bi- and tricompartment prostheses produced intermediate results (87 per cent). In RA results varied from 72 per cent for medial unicompartement prostheses to 90 per cent for bi- and tricompartment prostheses.

The main reason for failure was loosening of the components followed by infection. The probability of a revised infection at six years was two per cent in OA and three per cent in RA. Most revisions were performed with a tricompartment arthroplasty. The probability of knee fusion as a primary revision was 2 per cent at six years.

INTRODUCTION

Most reports on knee arthroplasty concern short-term or intermediate follow-ups. The safety of the procedure and the effect on pain, stability, and mobility are initially demonstrated by the innovators.

Two more factors are especially important in the evaluation of a knee arthroplasty, the clinical failure rate and the possibility for revision either with a new prosthesis or an arthrodesis. There is no consensus regarding the way of reporting varying degrees of success or failure. Failure rates are often presented as the fraction of different failures, general and local, after some arbitrary observation time. Different observation times make interpretation and comparison of results difficult since failure rate is time dependent. Some reports use scoring systems where failure can end up in a good result-

group. No generally accepted radiographic or clinical criteria for failure have thus been defined. To overcome these problems, the life table technique or survivorship method has been advocated². Even with the survivorship method, comparison of results is only valid if uniform definitions for failure are used. One way of defining a failure is to use the definite end-point for an arthroplasty, the revision of a complication. This definition has been used in a few survival studies with various prosthetic designs^{3, 5, 7-9}.

Tew and Waugh, 1982, suggested pooling of results from many centers in order to reach reliable results. In this report the survival rates of knee arthroplasties for osteoarthritis and rheumatoid arthritis have been estimated using data from a nation-wide multicenter investigation of 8 000 procedures performed in Sweden from October 1975 through 1983 .

MATERIALS AND METHODS

Selection of Patients

In October 1975 the Swedish Orthopaedic Society started a nation-wide computer survey of knee arthroplasties. Today 41 Swedish Departments participate in the study - "The Swedish Knee Arthroplasty Project".

Knee arthroplasties performed after the date of onset of the study have been reported for computer filing. The entry form contained information on knee condition, type of replacement, local or general antibiotic prophylaxis, duration of the hospital stay and local or general complications during the stay. The project was only intended for registration purposes and had no authority over participants. Participating units have therefore used their own indications for arthroplasty, choice of prosthesis and revision and their own criteria for complications. Each patient was followed for complications or revisions using a questionnaire one, three and six years after the operation. All patients who reported that they were not satisfied with the

4 446 Arthroplasties for OA

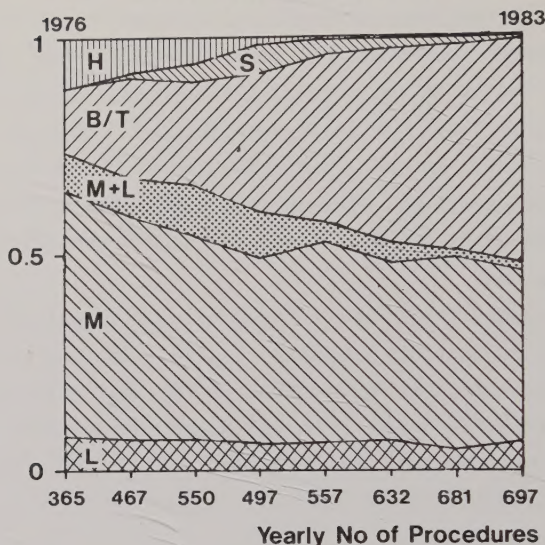


FIG. 1

The yearly relative distribution of the six main types of primary knee arthroplasty and the annual total number of procedures for osteoarthritis during 1976 - 1983. Hinge prostheses = H, stabilized pr. = S, bi- and tricompartment pr. = B/T, medial and lateral unicompartement pr. = M+L, medial pr. = M, and lateral pr. = L.

operation were seen by the surgeon at follow-up. At the end of 1983 the computer contained data on 8 000 primary arthroplasties for osteoarthritis and rheumatoid arthritis.

The main patient data are presented in Table I. The type of prosthesis used in the primary arthroplasty of knees with osteoarthritis (OA) and rheumatoid arthritis (RA) are listed in Table II. The changes in relative distribution between the six groups of arthroplasty from 1976 to 1983 are shown separately for OA (Fig. 1) and RA (Fig. 2).

3439 Arthroplasties for RA

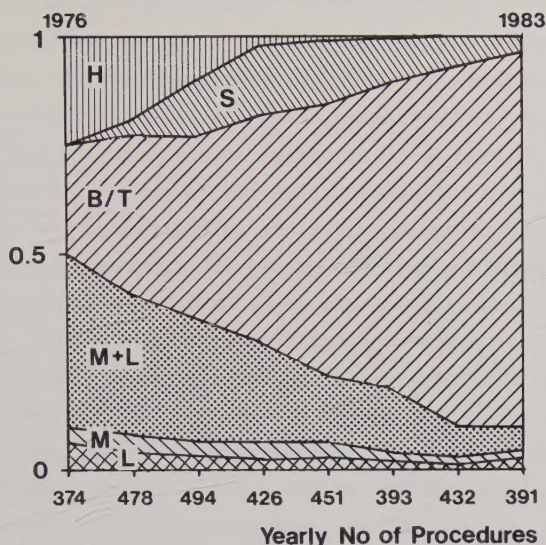


FIG. 2

The yearly relative distribution of the six main types of primary knee arthroplasty and the annual total number of procedures for rheumatoid arthritis during 1976 -1983. Hinge prostheses = H, stabilized pr. = S, bi- and tricompartment pr. = B/T, medial and lateral unicompartament pr. = M+L, medial pr. = M, and lateral pr. = L.

The Survivorship Method

In this report the survivorship method as described by Lee (1980) was used. Success was defined as the prosthesis remaining in situ at the end of the follow-up regardless of type of complications and clinical scoring. Consequently, failure was scored for arthroplasties where one or more prosthetic components had been added, removed or replaced. At the end of the survey, by December 31, 1983 the status of each arthroplasty was recorded. The length of the follow-up was determined for each arthroplasty

either to the end of the survey, the death of the patient or the date of revision or arthrodesis. Survivorship tables were then constructed using a one year interval. For each year after the primary operation the following was recorded: The total number of surviving arthroplasties entering the interval; the number of failures and the number of successes in patients who had reached the end of their follow-up during the interval; the number of patients at risk of being a failure calculated as the number of survivors reduced by half the number of successes; the yearly probability of survival calculated by dividing the number at risk reduced by the number of failures with the number at risk. Successes and failures were subtracted from the number of survivors to give the number of survivors to enter the next interval. The cumulated survival rate (CSR) was estimated by successive multiplication of the yearly values. The standard error (S.E.) of the CSR was calculated using the Greenwood estimate. Statistical analysis of CSRs was performed with Mantel and Haenzsel's Chi-Square Test⁶.

TABLE I
Basic Patient Data

	Osteoarthritis	Rheumatoid Arthritis
No. of arthroplasties	4,505	3,495
Mean age (years)	69.6	62.0
Std. dev. (years)	7.3	10.3
Age range (years)	32 - 91	18 - 87
Female fraction (per cent)	71	76
Dead during observation	498	653
Lost to follow-up (per cent)		
at one year	2.1	2.3
at three years	3.6	4.5
at six years	4.4	5.6

TABLE II

Type of Prosthesis

Type of prosthesis	Osteoarthrosis	Rheumatoid arthritis
Hinge	140	270
Guepar	104	224
St Georg	17	26
Walldius	18	17
Stanmore	1	3
Stabilized	102	296
Attenborough	58	224
Spherocentric	33	66
Sheehan	11	6
Bi- and tricompartment	1642	1962
Freeman-Swanson (ICLH)	425	642
Freeman-Samuelsson	15	18
Townley	431	501
Total Condylar	281	202
TCCK	148	89
PCA	69	77
RMC	64	59
Kinematic	20	21
Geotibial retractor	2	1
Geomedic	151	269
Deane	30	82
SKI	6	1
Unicompartment, Med. + Lat.	276	745
Marmor	214	526
St. Georg sledge	39	150
Lotus	10	14
Gunston-Hult	8	42
Charnley	4	2
Mixed	1	10
Savastano	-	1
Unicompartment, Medial	2051	114
Marmor	988	52
St. Georg sledge	714	41
Gunston-Hult	251+1*	16
Lotus	49	2
Mixed	22	2
Lund - prototype	13	-
Savastano	6	-
Charnley	4	-
Oxford	3	-
Geomedic uni	-	1
Unicompartment, Lateral	294	108
St. Georg sledge	131	50
Marmor	130	45
Gunston-Hult	29	10
Lund - prototype	3	-
Lotus	1	-
Mixed	-	2
Geomedic uni	-	1

*) Only the femoral component.

TABLE III

Cumulative Survival Rate of 4 504 Prostheses for Osteoarthritis

Interval (years)	No at Start	Failure	Survival Rate Cumulative (%)	No at Start	Failure	Survival Rate Cumulative (%)
Hinge			Stabilized			
0 - 1	140	7	95	102	3	97
1 - 2	129	16	83	91	4	92
2 - 3	107	12	73	75	2	90
3 - 4	89	4	70	61	4	83
4 - 5	78	3	67	38	0	83
5 - 6	65	2	65	15	0	83
6 -	40			2		
Bi- and tricompartment			Med. + Lat. Unicompartment			
0 - 1	1642	50	96.6	276	8	97.0
1 - 2	1212	33	93.5	254	9	93.5
2 - 3	857	13	91.8	232	7	90.5
3 - 4	577	13	89.3	195	5	88.0
4 - 5	364	5	87.8	161	0	88.0
5 - 6	211	2	86.7	113	1	87.0
6 -	111			59		
Medial Unicompartment			Lateral Unicompartment			
0 - 1	2050*	34	98.2	294	9	96.7
1 - 2	1710	34	96.1	235	2	95.8
2 - 3	1363	16	94.8	197	3	94.1
3 - 4	1083	17	93.1	147	5	90.5
4 - 5	810	8	92.1	111	0	90.5
5 - 6	600	10	90.2	87	2	88.0
6 -	366			53		

*) MV: One case, treated by femoral component alone, is excluded.

RESULTS

Survival rates

The observed number of arthroplasties, failures and the CSR for hinge, stabilized, bi- and tricompartment, medial and lateral and medial or lateral unicompartement prostheses are listed for OA (Table III) and RA (Table IV). The average yearly failure rate based on the initial six years after the operation varied in OA from seven percent for hinge prostheses to 1.7 per cent for medial unicompartement prostheses and in RA from 5.2 per cent for the latter prostheses to 1.7 per cent for bi- and tricompartment prostheses. The six-year CSR obtained by each participating unit was estimated for all arthroplasties performed disclosing a wide range (97 - 69 per cent) but with no correlation to the number of arthroplasties reported.

Osteoarthritis; the six-year CSR was 65 per cent for hinge prostheses and 83 per cent for the later introduced stabilized prostheses and the differences in CSR were statistically significant (Chi-square = 6.35, $P < 0.05$). The use of these prostheses has decreased very considerably in recent years (Fig. 1). The six-year CSR of surface replacements was better (86.7 - 90.2 per cent) with significantly better CSR for demi-arthroplasties with unicompartement prostheses compared with bi- and tricompartment prostheses (Chi-square = 10.87, $P < 0.001$). The individual CSRs for Total Condylar, Geomedic, Townley, various Freeman-Swanson, ICLH and Samuelson, and other bi- and tricompartment prostheses are illustrated in Fig. 3. The Freeman-Swanson, ICLH and Samuelson prostheses, including earlier bi- and later tricompartment designs with and without cruciate retention produced significantly lower CSR than all the other bi- and tricompartment prostheses (Chi-square = 17.30, $P < 0.001$). The CSR of medial unicompartement arthroplasties for OA was also divided into that of St. Georg sledge, Marmor and other designs (Fig. 4). The CSR of St. Georg sledge was slightly, although not significantly, better than that of the Marmor prostheses (Chi-square = 3.16, $P > 0.05$).

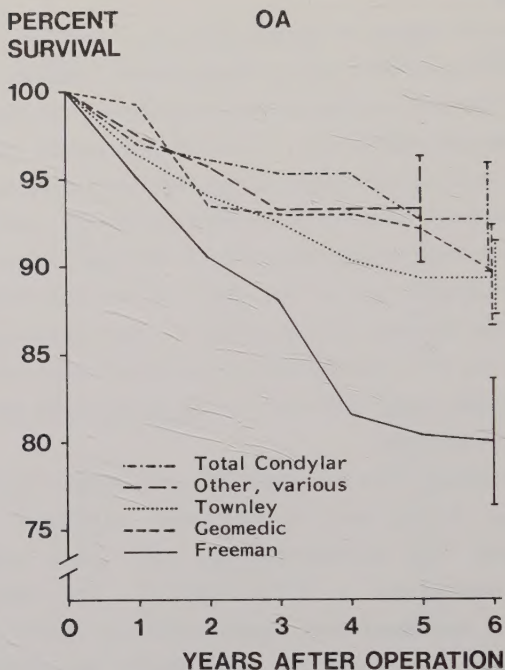


FIG. 3

Estimated cumulative survival rate and standard error at six years after the operation with bi- and tricompartment prostheses of various designs for osteoarthritis.

The six-year CSR of medial unicompart ment arthroplasties was also estimated for patients younger than 65 years of age (85.7 per cent) and older (92.5 per cent) ($P < 0.001$). The same age dependent variation was also observed for bi- and tricompartment prostheses.

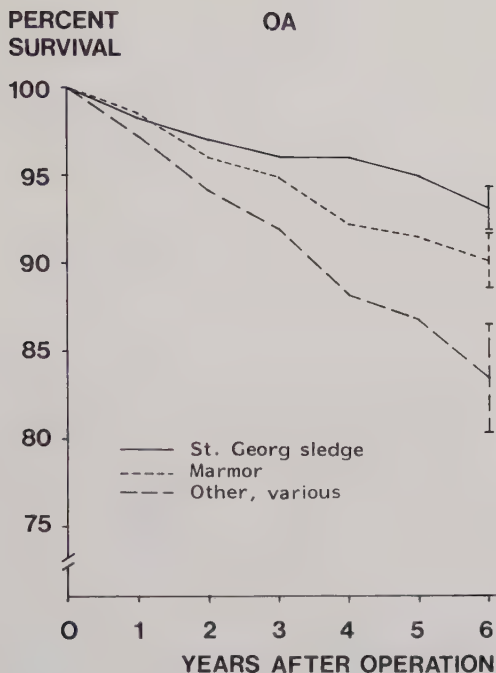


FIG. 4

Estimated cumulative survival rate and standard error at six years after the operation with medial unicompartement prostheses of various designs for osteoarthrosis.

Rheumatoid arthritis; the six-year CSR obtained by bi- and tricompartment prostheses was 90.1 per cent. The CSR of these prostheses was significantly better than those of hinge and stabilized prostheses (Chi-square = 4.24, $P < 0.05$), medial and lateral unicompartement prostheses (Chi-square = 10.25, $P < 0.01$),

TABLE IV

Cumulative Survival Rate of 3 495 Prostheses for Rheumatoid Arthritis

Interval (years)	No at Start	Failure	Survival Rate Cumulative (%)	No at Start	Failure	Survival Rate Cumulative (%)
Hinge				Stabilized		
0 - 1	270	7	97.4	296	2	99.3
1 - 2	257	13	92.3	274	8	96.2
2 - 3	230	3	91.1	226	5	93.7
3 - 4	217	7	88.0	165	1	93.1
4 - 5	191	8	84.1	109	3	89.7
5 - 6	163	2	82.9	54	2	84.3
6 -	112			10		
Bi- and tricompartment				Med. + Lat. Unicompartment		
0 - 1	1962	46	97.4	745	21	97.1
1 - 2	1544	22	95.8	690	16	94.8
2 - 3	1148	24	93.6	624	22	91.2
3 - 4	850	13	91.9	524	20	87.5
4 - 5	577	4	91.1	434	12	84.8
5 - 6	364	3	90.1	341	3	83.9
6 -	193			222		
Medial Unicompartment				Lateral Unicompartment		
0 - 1	114	5	95	108	2	98
1 - 2	94	5	90	94	4	94
2 - 3	77	3	86	80	4	89
3 - 4	66	6	77	67	6	80
4 - 5	46	1	75	48	0	80
5 - 6	30	1	72	39	2	75
6 -	20			29		

and demi arthroplasties with unicompartement prostheses (Chi-square = 26.90, $P < 0.001$). The CSR of bi- and tricompartment prostheses was further divided into that of Total Condylar, Townley, Geomedic, various Freeman-Swanson, ICLH and Samuelson and other bi- and tricompartment designs as illustrated in Fig. 5. The CSR pattern was the same as in OA but the differences were smaller and not statistically significant.

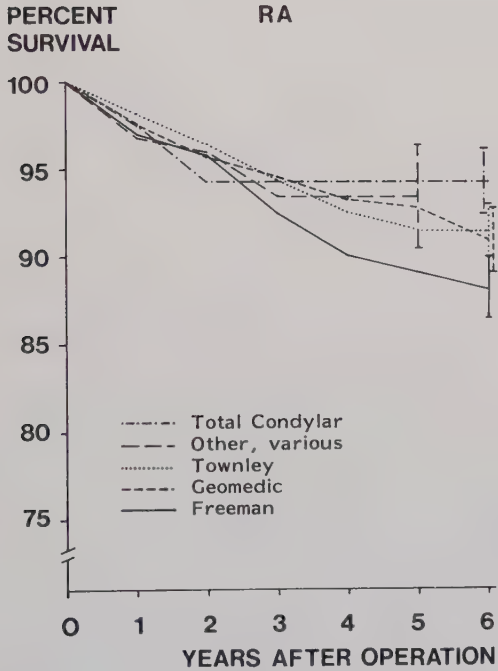


FIG. 5

Estimated cumulative survival rate and standard error at six years after the operation with bi- and tricompartment prostheses of various designs for rheumatoid arthritis.

Medial and lateral unicompartment arthroplasties (not demi-arthroplasties) were also further analysed but showed no significant differences. The six-year CSR was 86 per cent for St. Georg sledge, 83 per cent for Marmor, 84 per cent for the remaining prostheses of various designs. Poor six-year CSRs were obtained when using demi-arthroplasties for RA (72 -75 percent).

No age specific effects on CSR could be demonstrated in RA.

Type of Failure

The main indications for revision are listed in Table V. The most common cause of failure was loosening of prosthetic components, including subsidence, fractured or dislocated components. Hinge and stabilized prostheses failed, in declining order, because of loosening, infection, fractures and patellar pain. Bi- and tricompartment prostheses failed mainly because of loosening. Deep infection, which was especially common during the first and second postoperative year, was often secondary to wound healing disturbances, and often treated by knee fusion (Table VI). Other indications for revision were instability, malposition of components and patellar problems.

Loosening was the main cause of failure also for unicompartment prostheses. Infection was less of a problem. In medial and lateral unicompartment arthroplasty, instability was the second most important cause of failure, followed by malposition of components and to some extent patellar pain. Demi-arthroplasties were mainly revised because of secondary changes in the untreated compartment, and especially so in rheumatoid knees where this was the major cause of failure.

The cumulative probability of a revised infection was estimated with the survivorship method, withdrawing all other failures at the time of revision. The six-year rate of revised infections was in hinge arthroplasties for OA 16 per cent and for RA 8 per cent, in stabilized 2.5 - 3.3 per cent, bi- and tricompartment 2.0 - 3.2 per cent, and unicompartment arthroplasties 0.80 - 1.2 per cent. These differences in infection rates were significant when comparing hinge with bi- or tricompartment, and the latter with unicompartment arthroplasties for OA and for RA.

TABLE V

Indications for Revision During the Initial Six Years

Prosthesis	No	Infection	Loosening	Instability	Secondary arthropathy	Other
Osteoarthrosis						
Hinge	140	17	23	1	-	3
Stabilized	102	2	8	1	-	2
Bi-/ Tricomp	1642	23	54	22	-	17
Uni Med + Lat	276	1	17	11	-	1
Uni Medial	2051	10	48	10	26	25
Uni Lateral	294	1	9	3	5	3
Total	4505	54	159	48	31	51
Rheumatoid Arthritis						
Hinge	270	20	15	1	-	4
Stabilized	296	7	10	-	-	4
Bi-/ Tricomp	1962	41	51	10	-	10
Uni Med + Lat	745	8	46	29	-	11
Uni Medial	114	-	8	-	9	4
Uni Lateral	108	1	3	1	12	1
Total	3495	77	133	41	21	34

TABLE VI

Type of Primary Revision During the Initial Six Years

Components	No	Removed		Exchanged			Added			
		Amputa- tion	Arthro- desis	Hinge	Stabi- lized	Tricomp	Unicomp	Unicomp	Patella	
Osteoarthritis										
Hinge	140	1	18	17	4	2	-	-	2	
Stabilized	102	-	1	1	9	-	-	-	2	
Bi-/ Tricomp	1642	4	20	10	6	70	-	-	6	
Uni Med + Lat	276	-	5	4	6	8	7	-	-	
Uni Medial	2051	-	4	3	11	46	37	13	5	
Uni Lateral	294	-	-	-	2	8	8	3	-	
Total	4505	5	48	35	38	134	52	16	15	
Rheumatoid Arthritis										
Hinge	270	4	16	13	6	1	-	-	-	
Stabilized	279	-	4	2	12	1	-	-	2	
Bi-/ Tricomp	1962	5	23	4	10	66	-	-	4	
Uni Med + Lat	745	-	9	5	35	26	17	-	2	
Uni Medial	114	-	1	1	3	6	3	7	-	
Uni Lateral	108	-	1	-	2	6	2	7	-	
Total	3495	9	54	25	68	106	22	14	8	

A significant difference in revised-infection rate, computed with the life table technique was also established when comparing the total six year rate of OA (1.94 percent) with RA (3.07 percent) (Chi-square = 9.77, $P < 0.01$).

Type of Revision

The primary revisions, performed during the initial six years after the operation, are listed in Table VI. Failures in hinge arthroplasties were mainly treated by knee fusion. Stabilized prostheses were exchanged with the same design and surface replacements with tricompartment prostheses, the one exception being medial and lateral unicompartment prostheses. Translatory instability made it necessary to convert most of the latter to stabilized prostheses. Further revisions were performed in some cases but are not included in the present report. Also excluded are 108 soft-tissue procedures performed during the same period in the 8 000 arthroplasties. Using the life table technique, the six-year probability of receiving an attempted knee fusion as a primary revision procedure was estimated to be 1.7 per cent in OA and 2.5 per cent in RA. The six-year amputation probability was 0.3 per cent in OA and 0.4 per cent in RA. Reasons for amputation were infection, fractures and vascular diseases, not always related to the knee arthroplasty.

DISCUSSION

Using the survivorship method any defined end-point can be used. Three sets of definitions have so far been used in calculating the survival of knee arthroplasties; revision; revision or pain; revision, pain or definite complication³. The multicenter design of our study with many collaborators made it necessary to use an end-point that was easy to define. Only revision with removal, addition or exchange of prosthetic components met that demand. Pain in the knee region is not always useful since it is not objective or even constant and sometimes does not originate

from knee arthroplasty. If definite complications are used as an end-point the failure rate will not be influenced by whether revision is in fact performed or not. The problem will instead be to define all complications especially with regard to time of onset. There are no generally accepted criteria for definite complications, however, suggested criteria for radiographic loosening exist. If the diagnosis of a definite complication is delayed, for instance because of inadequate follow-up, the CSR will be lower because of the annually decreasing number of patients at risk. For the same reason CSR will be higher with more sensitive criteria, if failure at the same time is diagnosed earlier, as was found by Grimer et al. 1984.

The evaluation of our results must be made with the limitations of a survival study in mind. Hinge arthroplasties, for instance, are often difficult to revise because an exchange arthroplasty is a major surgical procedure and a knee fusion difficult to achieve⁴. It could be assumed that hinge arthroplasty complications are more often conservatively treated than a surface replacement complication. Furthermore, a large surgical unit may be more prone to perform revisions because of more experience, special interest and better equipment and choice of prostheses. A lower complication rate would then be counteracted by wider indications for revision, which possibly explains why no correlation was seen between the number of procedures and failure rates.

It cannot be assumed that OA and RA knees have the same inherent risk of failure especially with regard to the CSR of hinge or demi-arthroplasties. This is not to be expected when taking into account differences in mean age, bone quality, soft tissue problems, concomitant joint involvement, progression of a generalized disease, physical demands and activity level. A significant difference in infectious failure rate was demonstrated and the same has earlier been reported for the occurrence of haematogenous infections in prosthetic knees¹. Regardless of this, mixed materials are often presented and sometimes without even a statement on the number of OA and RA knees, thus thwarting the comparison of results.

The striking and inverted difference in infection rate between OA and RA hinge arthroplasties is enigmatic. The question is if loosening, created through interface stress in the fully constrained hinge design by the more active OA patient, produces a locus minoris resistentiae for late infections. The lower infection rate in the less constrained stabilized prostheses could also be due to their two to four year later introduction with improved operative hygiene.

A comparison of the survival data can be made with a recent material⁵ comprising 498 knee arthroplasties for RA from Lund, Sweden. The six-year CSR for all arthroplasties with unicompartement prostheses was reported to be 76 per cent (in the present study 83 per cent, derived from Table IV), for tricompartment prostheses 100 per cent (90 per cent), stabilized prostheses 82 per cent (83 per cent), and hinge prostheses 76 per cent (82 per cent).

Grimer et al. 1984, reported a six-year CSR of 81 per cent and Lettin et al. 1984, 83 per cent for Stanmore hinge arthroplasties where some two-thirds were RA knees. These values could be compared with a weighted average between RA and OA in this report producing a 75 percent CSR with mainly Guepar arthroplasties.

In a survival study by Tew and Waugh, 1982, 206 out of 365 arthroplasties were of early and later Freeman designs. The expected failure rate of the Freeman prostheses based on the CSR for all their arthroplasties was very close to the actual failure rate. The six-year overall CSR of 72 per cent thus indicates problems with this type of prosthesis and this is supported by our results (Fig. 3 and 5).

A comparison of results can also be made with a recent survival study on Gunston polycentric knee by Lewallen et al. 1984. They reported a six-year CSR of 90 per cent in OA (87 per cent in our study, Table III) and 82 per cent in RA (84 per cent, Table IV). In their definition of failure, however, one fifth were unrevised complications. They also demonstrated a continuing decrease in the annual survival rate throughout the ten year study.

When comparison is made with our nation-wide multicenter study, it must be remembered that the surgery was done by the average orthopedic surgeon. The results are, however, representative of a community and should not be expected to meet those from highly specialized knee units.

The bi- or tricompartment prosthesis seems to be the safest procedure for RA knees. In the few cases where stability cannot be achieved a stabilized prosthesis is an alternative, leaving the hinge arthroplasty for complicated revision surgery only. Demi-arthroplasties for RA are unpredictable because of the risk of further deterioration of the untreated compartment in cases with active disease.

In OA, demi-arthroplasties give better CSR than bi- and tricompartment arthroplasties. Since there were fewer infections and instability problems with demi-arthroplasties and since failure usually could be revised using a tricompartment arthroplasty, demi-arthroplasty must be the choice in older patients with early gonarthrosis. Technical improvements already used for tricompartment prostheses are now being introduced in unicompartement prostheses with guide instruments and metal backing. It remains to be seen if these improvements will further reduce the already low failure rate.

Since OA does not usually cause severe ligamentous instability most knees with more advanced changes are safely treated by tricompartment prostheses. The problem of early infections that are mainly secondary to wound healing disturbances and dehiscence may be due to oversized implants and extensive release procedures putting excessive strain on the wounds. This could probably be overcome with better technique.

Dobbs, 1980, extrapolated his results on metal-to-plastic hip arthroplasties to predict the 20-year CSR, assuming an exponential distribution of failure times, and arrived at 74 percent. Optimal knee arthroplasty technology, using tricompartment prostheses in RA and unicompartement demi-arthroplasties in focal medial OA, produces comparable results with a predicted 20-year CSR of 71 percent based on the results of this nation-wide survey.

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